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U.S. Patent Nov. 15, 1994 Sheet 1 of 9 **5,365,458**

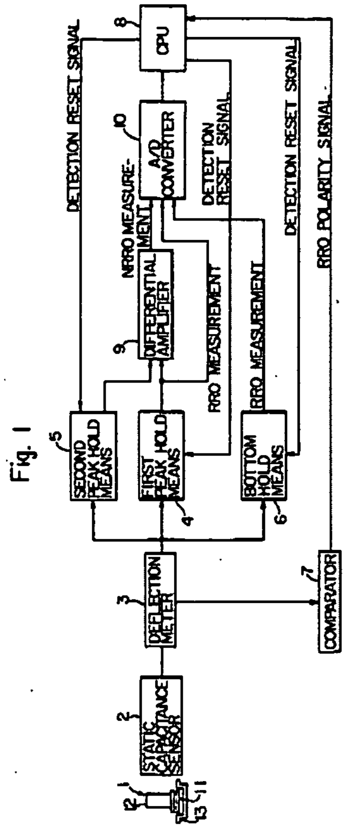

Fig. 1

means respectively when the input signal of the second shift means is positive;

FIGS. 7-A and 7-B are diagrams showing an input signal and an output signal of the first shift means respectively when the input signal is negative;

FIGS. 8-A, 8-B, and 8-C are diagrams showing an input and an output signal of the second shift means and an output signal of the polarity inverse means respectively when the input signal of the second shift means is negative; and

FIG. 9 is a schematic view showing a mechanism of installation of a sensor.

DETAILED DESCRIPTION:

(1) DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

(2) A motor eccentricity measuring apparatus according to a first embodiment of the present invention will be described referring to FIGS. 1 and 2.

(3) As shown in FIG. 1, a spindle motor 1 to be examined is provided with a bracket 11 and a hub 12 arranged for rotation relative to the bracket 11. Also, a bearing member (not shown) is mounted on the bracket 11 so that it can rotate together with the hub 12. The hub 12 is coupled to a recording medium, e.g. a magnetic disk, by a known manner.

(4) First, the spindle motor 1 which has fully been assembled is carried on a transfer table 13 to a measuring station where a static capacitance sensor 2 is installed for measurement of a distance to the hub 12 of the motor 1. The sensor 2 is arranged for detecting a change in the distance to the surface of the hub 12 and translating it to a capacitance variation which is then delivered as a voltage output of measurement to a deflection meter 3.

(5) The deflection meter 3 calculates a shaft runout of the motor from the voltage measurement of the static capacitance sensor 2 and then, transfers it to two, first and second, peak hold means 4 and 5 and a bottom hold means 6. Also, a comparator 7 is provided for producing a square wave corresponding to a deflecting direction signal of the deflection meter 3 and transmitting it to a CPU 8 which may be a microprocessor. In response to the square wave of the comparator 7, the CPU 8 delivers a detect/reset signal to the two peak hold means 4 and 5

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EAST Advanced Find

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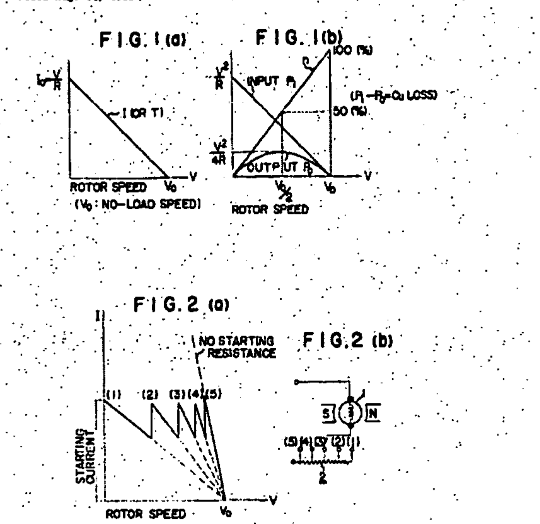
Sept. 2, 1969 KIYO TAKEYASU 3,465,224

BRUSHLESS DIRECT-CURRENT MOTOR

Filed Aug. 30, 1965 5 Sheets-Sheet 1



INVENTOR
Kiyo Takeyasu
BY

L9: (39) ((Hall adj g... | USOCR | US 3465224 A | Tag: S | Doc: 39/39 | Format : KWIC

US-PAT-NO: 3465224

DOCUMENT-IDENTIFIER: US 3465224 A

TITLE: BRUSHLESS DIRECT-CURRENT MOTOR

OCR Scanned Text - LPAR (7):

3,465,224 3 Furthermore, a feature of a D-C shunt motor is that, by taking its rated speed in the nei.- hborhood of its noload speed, the spe,-d fli-ictiiation is kept low, and the efficiency is caus-.d to be high. Accordingly, the motor is so designed that the rated speed approaches its no-load speed as much as possible to obtain sufficient mechanical output. It is apparent from the above two points that if the power source voltage V were applied to the motor at starting, not only would a great load be imposed on the power source, but there would arise the risk of heat or buming dama.-e to the armature winding. For this reason, it is the ordinary practice, as indicated in FIGS. 2(a) and 2(b), to start a motor I as the armature current is pre- vented from exceeding a certain value by using a series resistance 2 at the time of starting and to short-circuit this resistance after the rated speed has been reached. That is, in a D-C shunt motor, it is desirable that limit- ing of the current be accomplished by causing the resist- ance valtie of the armature winding to be high at the time of starting, to decrease as the speed increases, and to be- come a specific value at the rated speed. As is further known, the operational principle of a br-ushless D-C motor of the type wherein the rotor position is detected, and the rotation is maintained by switching the polarity or the magniude of the annature current in accordance with the detected rotor position, such 8s, for example, a brushless D-C motor in which a Hall generator is used as the rotor position detector, is the same as the operational principle of a D-C shunt motor. - Accordingly, the various characteristics of a brushless motor of this type are also similar to those of the motor in the case illtistrated in FIG. 1. The principle of one example of a conventional brush- less D-C motor of this type in which a Hall generator is used is indic-,Lted in FIG. 3. Rotation of a magnet rotor 3 causes a current and a speed E.M.F. E to be produced in an armature winding 4, the speed E.M.F. E becomin.@ large in proportion to the rotational speed. The bias volt- age between the collectors and emitters of transistors Ti-I and Tr2 becomes V-E and is in inverse proportion to the speed. On the other hand, the output of a Hall gen- erator 5 which is the base input is constant - irrespective of the rotational speed. Accordingly, the following equa- tion, which is the same as Equation 1, is obtained. I=V-E R where R is the armature resistance. That is, the characteristics

Details | Text | Image | HTML | KWIC

37	☑	☐	US 3652909 A	19720328		RELUCTANCE MOTORS AND BRUSHLESS STEPPING MOTOR	318/
38	☑	☐	US 3643118 A	19720215		ROTARY MACHINE	310/
39	☐	☐	US 3465224 A	19690902	9	BRUSHLESS DIRECT-CURRENT MOTOR	318/

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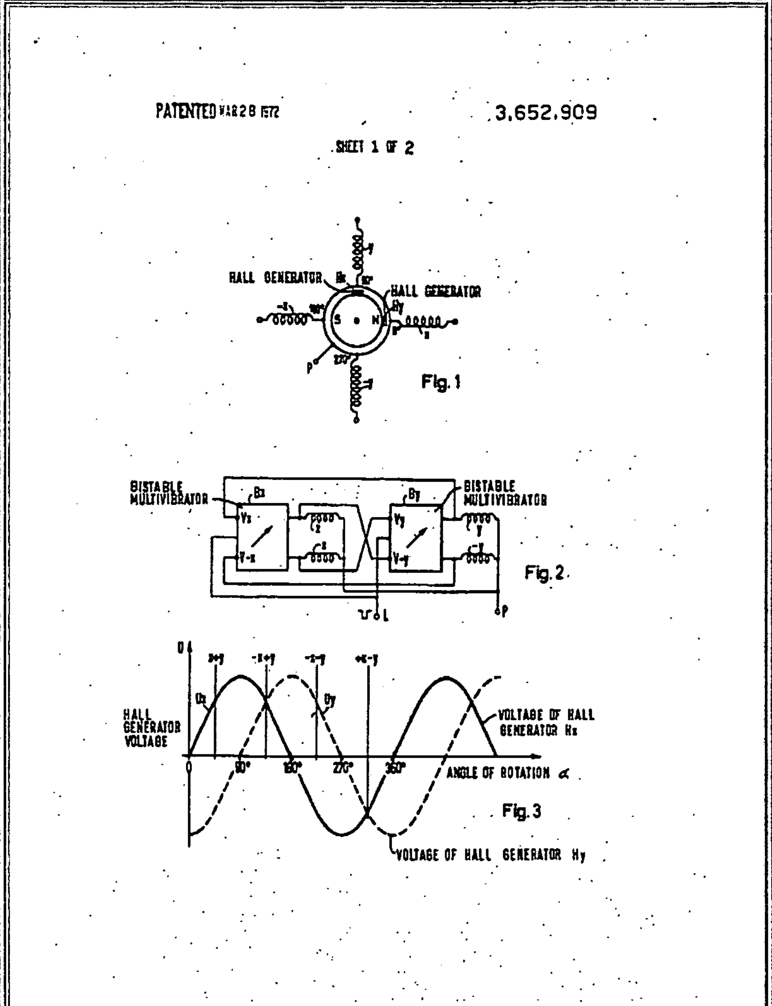

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L9: (39) ((Hall adj g... | US 3652909 A | Tag: S | Doc: 37/39 | Format: KWIC

US-PAT-NO: 3652909

DOCUMENT-IDENTIFIER: US 3652909 A

TITLE: BRUSHLESS STEPPING MOTOR

Drawing Description Text - DRTX (4):

FIG. 3 is a graphical presentation of the voltages provided by the Hall generators in accordance with the instantaneous rotor position; and

Detailed Description Text - DETX (19):

The individual switching transistors T1, T2, T3 and T4 are cyclically controlled by four capacitors C1, C2, C3 and C4. The capacitors C1 and C2 are connected to each other, the capacitors C3 and C4 are connected to each other and a common point in the connection of each is directly connected to the other. The capacitors C1 to C4 are cyclically controlled via a resistor R17 connected to the positive polarity terminal of the source of current. The electrode of the capacitor C1 which is not connected in common with the other capacitors is connected to the switching input Vx of the flip flop Bx. The electrode of the capacitor C2 which is not connected to the other capacitors is connected to the switching input V-y of the flip flop Bx. The electrode of the capacitor C3 which is not connected to the other capacitors is connected to the switching input Vy of the flip flop By. The electrode of the capacitor C4 which is not connected to the other capacitors is connected to the switching input V-y of the flip flop By. The switching input Vx is connected to the positive polarity terminal P of the current source via a resistor R18. The switching input V-x is connected to the positive polarity terminal P of the current source via a resistor R19. The switching input Vy is connected to the positive polarity terminal P of the current source via a resistor R20. The switching input V-y is connected to the positive polarity terminal P of the current source via a resistor R21. The switching input Vx is coupled to the base electrode of the transistor T1 via a diode D1. The switching input V-x is coupled to the base electrode of the transistor T2 via a diode D2. The switching input Vy is coupled to the base electrode of the transistor T3 via a diode D3. The switching input V-y is coupled to the base electrode of the transistor T4 via a diode D4.

Detailed Description Text - DETX (20):

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						RELUCTANCE MOTORS AND	
37	☐	☐	US 3652909 A	19720328	6	BRUSHLESS STEPPING MOTOR	318/
38	☐	☐	US 3643118 A	19720215	14	ROTARY MACHINE	310/
39	☐	☐	US 3465224 A	19690902	9	BRUSHLESS DIRECT-CURRENT MOTOR	318/

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United States Patent

Bedford

[11] 3,679,953

[45] July 25, 1972

[54] COMPATIBLE BRUSHLESS RELUCTANCE MOTORS AND CONTROLLED SWITCH CIRCUITS

[72] Inventor: Bernice D. Bedford, Scotia, N.Y.

[73] Assignee: General Electric Company

[22] Filed: Nov. 6, 1970

[21] Appl. No.: 87,258

[52] U.S. Cl. 318/138, 318/138, 318/166, 318/254

[51] Int. Cl. H02k 29/00

[58] Field of Search 318/138, 166, 254, 685, 696

[56] References Cited

UNITED STATES PATENTS

3,374,410	3/1968	Cronquist	318/138
3,127,548	3/1964	Van Emden	318/138
3,486,096	12/1969	Van Cleave	318/138
3,530,347	9/1970	Newell	318/138

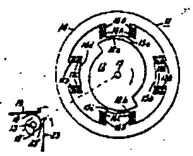
Primary Examiner—Gene Z. Rubinson

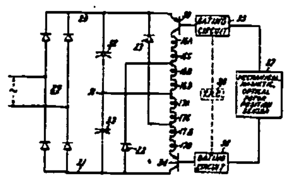
Attorney—Paul A. Frank, John F. Ahern, Julius J. Zaskalicky, Donald R. Campbell, Frank L. Neuhauser, Oscar B. Waddell and Joseph B. Forman

[57] ABSTRACT

Brushless reluctance motors are compatible with energization by the simple rectilinear voltages easily produced by motor control circuits having a small number of mechanical or solid state switches. These motors with two or three opposing pairs of main and feedback stator windings, and suitable variable or constant gap nonpolarized rotors, require a like number of controlled switches and uncontrolled rectifiers actuated by a rotor position sensor to generate square wave voltages on which the reluctance motors operate efficiently.

11 Claims, 8 Drawing Figures





The other set of stator windings 17A-17D are then energized when gating circuit 36 turns on transistor 34, as previously explained. Feedback diode 23 similarly conducts current to these windings during the nonconducting intervals of time ratio control operation, and returns magnetic energy when transistor 34 is turned off for longer periods of time.

Detailed Description Text - DETX (11):

The motor control circuit of FIG. 2b is similar to the FIG. 1b control circuit with the exception of the addition of the third set of windings and the replacement of the mechanical switches by transistor switches 42-44. An additional feedback diode 45 is in series with each of the feedback windings 18B and 18D. To provide gating signals for transistors 42-44 that are timed in dependence upon the rotor position, a plurality of magnetic sensors in the form of Hall elements or generators 46-48 are assembled about an extension of the motor shaft 13 and actuated by a permanent magnet 49 secured for rotation with shaft 13. Sensors of this type which operate on the Hall effect principle generate an output voltage between the two output terminals when a magnetic field is applied perpendicular to the face of the Hall element and an energizing control current is applied between the two input terminals, normally aligned with the longitudinal axis of the element. Further information on the Hall generator itself and its utility as a rotor position sensor in a brushless motor can be obtained from the prior art patents, as for example, U.S. Pat. No. 3,159,777 to E.W. Manteuffel, granted Dec. 1, 1964 and assigned to the General Electric Company. Although in the interest of simplicity it may be desirable to use six Hall generators to sense the rotor position at 60.degree. intervals, it is also possible to use the three Hall generators 46-48 spaced at 120.degree. intervals as illustrated, provided that the control current is reversed twice during each revolution of the permanent magnet 49. The output terminals of Hall generators 46-48 are connected to a gating circuit 50 for transistor switches 42-45. If desired, the gating circuit 50 may also be under the control of a time ration control circuit 51 to change the speed of the motor as previously explained.

Claims Text - CLTX (21):

said circuit means includes a pair of unidirectional voltage power supply terminals between which are connected a pair of voltage divider capacitors, each pair of opposing main and feedback stator windings being connected in series with one another and with the respective controlled switch device between one power supply terminal and the junction of said voltage divider capacitors, the respective uncontrolled rectifier being connected between the other power supply terminal and the junction of said pair of main windings and pair of feedback windings, and

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						RELUCTANCE MOTORS AND	
37			US 3652909 A	19720328	6	BRUSHLESS STEPPING MOTOR	318/
38			US 3643118 A	19720215	14	ROTARY MACHINE	310/
39			US 3465224 A	19690902	9	BRUSHLESS DIRECT-CURRENT MOTOR	318/

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L9: (39) ((Hall adj g... | US 4734603 | Tag: S | Doc: 21/39 | "Full" 2/5 (Total images 5) | Drawings

U.S. Patent Mar. 29, 1988 Sheet 1 of 2 4,734,603

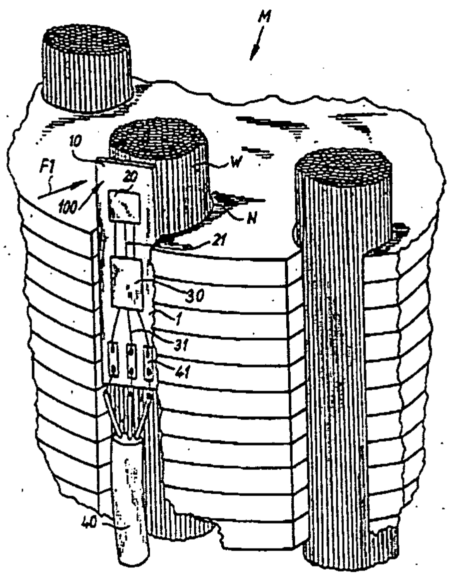

Fig.1

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US-PAT-NO: 4734603

DOCUMENT-IDENTIFIER: US 4734603 A

TITLE: Motor control mounting

Brief Summary Text - BSTX (13):

The main advantage of this arrangement is that it provides a space-saving means of locating the Hall generator in the stator in the upper part of the rotor housing of a motor provided with an external rotor. In this area, the permanent magnet field is very strong, whereas the stray field will be very weak, and the arrangement is almost completely protected against outside influences.

Detailed Description Text - DETX (3):

The supply and output leads from the amplifier are run in bonding wiring 31 to the solder support points 41, to which can be connected the power leads 40 from the power supply (not shown) and from a capacitor as well, if needed.

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						physical parameter
19	☐	☐	US RE34609 E	19940517	21	Collectorless direct current moto circuit for a drive and method of
20	☐	☐	US 4804892 A	19890214	19	Collectorless direct current moto circuit for a drive and method of
21	☐	☐	US 4734603 A	19880329	5	Motor control mounting
22			US 4644157 A	19870217	18	Optical rotation detecting appara

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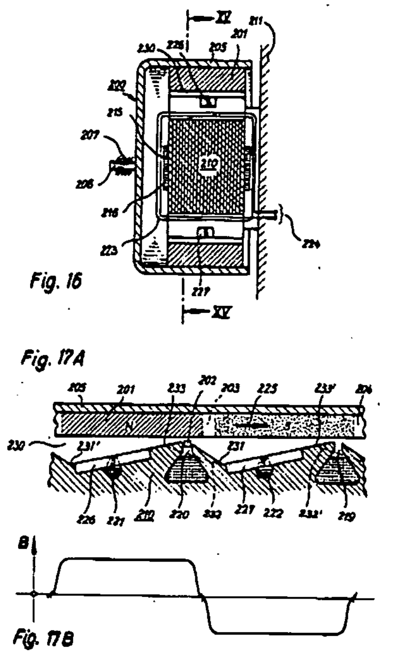
PATENTED JUN 24 1975 3,891,905

SHEET 8



US-PAT-NO: 3891905

DOCUMENT-IDENTIFIER: US 3891905 A

TITLE: Brushless d-c motor

Abstract Text - ABTX (1):

A transducer, such as a Hall generator is located on the stator to control a semiconductor switching element, such as a transistor, in series with the winding of the motor to pulse the winding and generate a driving torque which interacts with the magnets of a permanent magnet rotor. The stator has located thereon a permanent magnet arrangement, for example a single permanent magnet or a plurality which is positioned to generate, together with angular position selective reluctance torque generating means, an additional driving torque in those angular ranges of position of the rotor during which no driving torque is supplied by the pulsed winding, so that the overall torque being applied to the motor, during a revolution of the rotor, is essentially free from gaps. The permanent magnet on the stator is preferably so located that a portion thereof is outside of the rotor field to decrease demagnetizing effects.

Brief Summary Text - BSTX (2):

The present invention relates to a brushless d-c motor having a permanent magnet (PM) rotor, and a transducer element, such as a Hall generator on the stator to control current flow through the motor winding in dependence on the instantaneous angular position of the rotor with respect to the transducer element, that is, with respect to the stator and the winding thereon.

Detailed Description Text - DETX (20):

Rotor 26 will reach a position in which the poles of the magnet 27 will be opposite equal poles of the rotor, after the quarter revolution above described. The rotor will continue to rotate out of this position and will receive a drive torque 64 (FIG. 12, graph b) which overcomes the gap in the electrical torque M.sub.el seen at 65 in graph a of FIG. 12 and, further, the braking torque due to the elements 45, 46. This torque seen at 64 will be effective for approximately a further quarter revolution

29			US 3940670 A	19760224	9	Speed control apparatus for a D.C having hall generators
30			US 3898544 A	19750805	11	DC brushless motor
31		☑	US 3891905 A	19750624	21	Brushless d-c motor
32			US 3873897 A	19750325	11	Collector-less D-C motor

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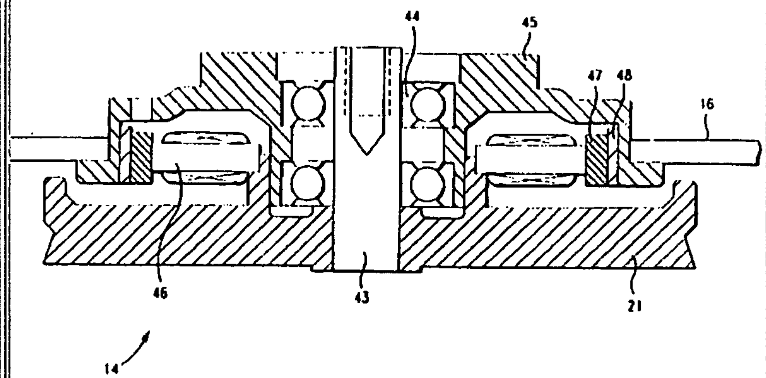

FIG.-2

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US-PAT-NO: 5798623

DOCUMENT-IDENTIFIER: US 5798623 A

TITLE: Switch mode sine wave driver for polyphase brushless permanent magnet motor

Abstract Text - ABTX (1):

A switch mode sine wave driver circuit selectively sources and sinks driving currents to and from a DC brushless motor in accordance with the substantially sinusoidal switched driving signals. A signal waveform monitoring circuit monitors electrical signals appearing the motor windings and puts out motor phase reference signals. A phase clock generator provides a motor -synchronized clock signal. A phase counter is clocked by the motor clock signal and is reset by the motor phase reference signals. The phase counter counts predetermined phase intervals and generates phase counts and phase polarity signals. A motor state decoder responds to the phase polarity signals by generating state control signals. Sine wave logic circuitry is addressed by the phase counts and puts out digital polyphase sine values for each one of the polyphases. A polyphase pulse width modulator circuit responds to the polyphase sine values by generating phase pulses having duty cycle duration controlled by the sine values. A logic decoder responds to the state control signals by decoding the phase pulses into phase driving pulses and by supplying the phase driving pulses to control a polyphase motor driver bridge circuit in order to rotate the motor.

Brief Summary Text - BSTX (2):

The present invention relates to electronic circuits for driving polyphase brushless permanent magnet motors. More particularly, the present invention relates to a switch mode sine wave driver circuit for driving a brushless permanent magnet motor, such as a spindle motor for a disk drive, with switched positive and negative (full wave) sine wave excitation resulting in significantly lowered electrical and acoustical noise emanating from the motor and in a manner enabling simultaneous precise regulation of motor speed.

Brief Summary Text - BSTX (4):

It is known to employ electronically commutated DC brushless permanent

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						source modulation for	
9	☑	☐	US 6172474 B1	20010109	58	Motor with electronic distributing configuration	318/
10	☐	☐	US 5798623 A	19980825	21	Switch mode sine wave driver for polyphase brushless	318/
11	☐	☑	US 5796231 A	19980818	35	Rotation position detecting device and motor device	318/

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